HazMat Care/ Decontamination H-01

With radioactive material exposure (*different from chemical exposure*) once the patient is removed from the environment, medical care supersedes decontamination.

Provide Basic Respiratory & Hemodynamic Support:

- **100% Oxygen by Non-Rebreather**, as per Airway/O2 Maintenance [A-01]
- **IV/IO Access**, per IV Protocol [1-03]
- **Fluid Resuscitation and Vasopressors**, per Medical Shock [M-06]

Monitor for signs of **Acute Radiation Sickness**

- Document time of exposure and onset time of GI Symptoms (vomiting).
- Antiemetics (Zofran) per Abdominal Pain/Vomiting [M-01]

Basic Decontamination/Wound/Burn Care:

1. Brush off any solids/particulates.
2. Remove jewelry and contaminated clothing.
3. **Wipe off** any wounds or potentially affected skin using towels with soap and warm water (or baby wipes).
    a. *Irrigation of wounds/skin/eyes should only be initiated if the fluid (effluent) can be collected in appropriate containers for proper disposal.*
4. Collect all particulates, clothing and dirty towels/effluent in plastic bags for proper disposal.
5. Cover burned/exposed areas with dry sterile dressings/ burn sheet. Dress any wounds as per usual fashion.

INITIAL RESPONSE

- If there is concern over continued exposure, the patient(s) should be removed from the source/ environment (or have the source removed) in as rapid and safe manner as possible.
- If there is ever a question a HazMat Team should be requested to evaluate the scene and develop an extrication and treatment approach.
- ALARA (As Low As Reasonably Achievable) is the underlying philosophy associated with protecting patients and providers from ionizing radiation. *Minimize the time around the source, increase the distance from the source, put "stuff" between the target and the source (shielding), and/or simply remove the source.*
- Once removed from the source, lifesaving interventions take priority over contamination concerns.
  - **A non-contaminated patient who has only been irradiated poses no radiological hazard to the healthcare provider, and**
  - **The use of universal precautions by healthcare professionals has been shown to mitigate clinically-significant exposure from radioactive contamination.**
- MCI: Multiple casualties should be managed based on current MCI Triage (START) standards.
- *Dose estimation*: HazMat Specialists should safely obtain an estimate of the exposure in order to prepare an effective treatment plan. Measurements/calculations of the source activity (A), the isotope and corresponding gamma constant (Γ), the distance the victim was from the source (m or cm), and the time in the area (t) are needed if possible.

ACUTE RADIATION SICKNESS/SYNDROME (ARS)

- ARS results from whole-body, external exposure to radiation doses >1 Gy delivered over a short time period (i.e. acute, high dose exposure). Onset of symptoms varies from a few hours to weeks, depending on the degree of exposure.
- *Pathophysiology*: radiation damage to cells occurs within microseconds of exposure. This is most severe in rapidly reproducing cell types → stem cells in the bone marrow, intestinal crypt cells, and the basal layer of skin.

Clinical Syndromes

<u>Acute</u> = Gastrointestinal Syndrome

- Symptoms generally begin with nausea/vomiting and diarrhea. Severe acute symptoms can lead to significant fluid and electrolyte shifts, malabsorption of nutrients, GI bleeding, and eventually sepsis.
- The **time to onset** of signs/symptoms is <u>dose-related</u>, with a more rapid onset indicating a higher dose. "Biological Dosimetry" = estimated radiation dose utilizing clinical signs and symptoms.
- <u>Time to emesis:</u> <1 hour = >6-8 Gy; 2 hours = 4 Gy; 4 hours = 2 Gy. *The absence of vomiting does not preclude a significant exposure.*

Subacute = **Hematopoietic Syndrome** (Bone Marrow Suppression)

- Mature lymphocytes and cells in the bone marrow are highly sensitive to radiation. Exposure (damage) leads to lymphopenia followed by anemia and thrombocytopenia.
- Clinical manifestations typically occur over a few weeks with morbidity and mortality related to bleeding and infection.
- *Thresholds*: >1 Gy = laboratory detection of hematopoietic changes (decreased lymphocyte count) and >2 Gy causes clinically significant hematologic-related illness.
- Modern supportive care (including blood products, hematopoietic growth factors, and antimicrobials) is capable of significantly improving survival, and is intended to maintain the patient until surviving islands of stem cells can be stimulated to resume blood cell production.

Lethal Exposure = **Neurovascular Syndrome**

- Occurs at doses of >8 Gy or greater with irreversible, non-survivable state at doses > 10 Gy.
- Nausea and vomiting occur *within minutes*.
- Early transient incapacitation (loss of consciousness) can occur. There may be a short (latent) period of the return of some functionality from a few hours up to a few days, followed by a deterioration of the patient's status. Cerebral edema and multiple organ pathology are often seen during autopsy.

Injury to Other Organs

- Ionizing radiation may cause injury to the lungs, liver, kidneys, and other organs.
- Multi-organ failure (MOF) results from maldistribution of blood flow that occurs after radiation-induced systemic inflammatory response syndrome (SIRS). The pathogenesis of MOF is not fully known.

MEDICAL MANAGEMENT

- Prehospital Care:
  - Other than gastrointestinal symptoms (i.e. vomiting), there are rarely other immediate emergent medical concerns directly related to the radiation.
  - Treatment should focus on *supportive care, decontamination* and the evaluation of secondary injury or illness.
  - EMS personnel should obtain a complete history, including timing/duration of exposure as well as <u>documenting any loss of consciousness</u> and <u>any vomiting episodes</u> as these two historical markers will provide future healthcare providers with an estimate of the degree of exposure and subsequent likelihood of deterioration/death.
- Additional Evaluation/Treatment:
  - The overall management of ARS is focused mainly on physiologic support while awaiting the recovery of the hematologic system.
  - Routine labs allow calculation of the *absolute lymphocyte count (ALC)* with a rapid and deep decrease in the ALC indicating a high dose.
  - The goals of medical management are aimed at preventing, monitoring for, and treating sepsis, and providing appropriate respiratory and hemodynamic support.

Radiation Burns (Local Injury)

- The pathophysiology for erythema includes arteriolar constriction, capillary dilation and local edema. Over time, endothelial cell damage and fibrinous necrosis can lead to radionecrosis and ulceration.
- There may be some immediate erythema of the skin, but radiation burns develop 2-4 weeks post-exposure. **Immediate burns should be assumed to be related to thermal or chemical injury and treated as such.**
- Thresholds are as follows:
  - 3 Gy: Epilation, typically 2-4 weeks post-incident
  - 6 Gy: Immediate but transient erythema in a few hours post-accident (primary erythema) with secondary erythema 2-4 weeks thereafter.
  - 10-15 Gy: Dry Desquamation (first-degree burn/sunburn) of the skin is usually seen approximately 2-4 weeks post-incident.
  - 15-25 Gy: Moist Desquamation (partial thickness/2nd-degree burns with blisters and denuded skin) is seen at least 2-4 weeks post-exposure, depending upon dose.
  - > 25 Gy, overt radionecrosis (i.e. full thickness/3rd-degree burn), extending to deep structures and with likely whole body radiation illness.
- *Treatment*: standard wound/burn care, infection control and appropriate pain management.

DECONTAMINATION

- **Radiologically contaminated patients generally pose no danger to healthcare personnel.**
- Perform all immediate life-/limb-saving actions without regard to contamination.

- *Radiological decontamination,* that is, the removal of radioactive materials from surfaces, *demands significant resources/time, and should generally be deferred to a HazMat Specialist.*
- Unlike chemicals, radioactive materials cannot be "neutralized", they can only be moved from one point to another. Therefore, the challenge is to remove the radioactive material from one area and transfer it to where you want it to be without spreading it to points in between.
- Decon is performed similar to chemical decontamination, the main difference is in *timing*: Chemical decon is often an emergency, but *radiological decontamination is not an emergency.*

PROCESS

- A quick head-to-toe survey should provide sufficient evidence of the presence or absence of gross contamination with appropriate instrumentation.
- First, brush off particulates, and remove clothing.
- Then → formal decontamination:
  - **1st = Wounds:**
    - The intact skin immediately adjacent to the wound should be quickly decontaminated using a moist towel/baby-wipe (wipe away from the wound).
    - Irrigation using sterile saline or water may be considered *if the effluent can be collected and the runoff will not cross-contaminate clean areas of the body*. The goal is gentle irrigation to remove the bulk of the contamination and avoid splashing. Drapes and/or absorbent pads should be applied and any runoff should be directed into a receptacle (e.g. a lined garbage can).
    - The wound should then be covered and clean, absorbent towels/pads should be placed under the affected area prior to resurvey.
  - **Mouth & Nose** (prevent ingestion): Have the patient blow their nose for particulates. Mucous membranes may be wiped with most towels, similar to skin, but irrigation of the airway should generally be avoided.
  - **Eyes**: Irrigation (i.e. with a morgan lens) may be considered if effluent can be collected.
  - **Intact Skin/Hair**: Once wounds have been addressed, other contaminated intact skin should be wiped (and/or washed/irrigated) similar to a wound.
- All waste and effluent (irrigant) should be kept for later collection and disposal.
- Repeat contamination surveys (measurements) to determine the effectiveness of the decontamination attempts, and the process should be repeated until no further progress is made.

NOTES/DEFINITIONS

- "Irradiation" = the patient is exposed to ionizing radiation/radioactive environment, but no material is transferred. This means that an irradiated patient *has no radioactive material on them and poses <u>no radiological hazard</u> to the treatment team*.
- "Contamination" = the patient has radioactive materials on/in them (i.e. a material that emits radioactive particles or waves).

- *Activity/Radioactivity* = the amount (*quantity*) of radioactive material present.
  - Measured in Curies (Ci) in the U.S., and is defined as 3.7 x 10^{10} becquerels (37 giga-becquerels (GBq))--the becquerel is the basic SI unit for one disintegration per second.
  - Conventional units such as ounces, grams, etc. are not used.
- Exposure = the potential to create ionization in air = danger of the environment.
  - The units are the Roentgen (R) in the U.S. (Coulombs per kilogram in SI units).
- *Absorbed dose* = energy deposited into tissue = *<u>damage</u>*
  - Measured in **Rads** in the U.S. One rad is equal to 100 ergs (10^{7} joules) of energy deposited into one gram of tissue.
  - The SI unit is the gray (Gy), which is equal to one joule of energy deposited into one kilogram of tissue → 1 Gy = 100 Rads.
  - The absorbed dose is the most common and most appropriate measurement used in patients as it correlates with the acute injury/effects from radiation.
- Dose-equivalency = differences in the future risk between the different radiation types.
  - Use a quality factor (QF, in the U.S.) or a radiation weighting factor (wR, internationally).
  - Basically, the QF/wR represent how much more risk (i.e. risk of future cancer) is associated with one radiation type versus the standard (gamma/x-ray where the wR and QF = 1).
  - SI = measured in Sieverts (Sv) the equivalent dose = the dose in Gy times the wR.
  - US = measured in rem = the dose in Rads times the QF.

Types of Radiation

- Alpha (α) particles:
  - Charged particles made up of two protons and two neutrons emitted from heavy nuclei.
  - Cannot travel far (about an inch in air) and cannot penetrate the skin.
  - Thin clothing or even a sheet of paper are effective shields for alpha particles. Radionuclides that emit alpha particles are therefore a *negligible external hazard but can be more dangerous in an inhalation or ingestion incident.*
- Beta (β) particles:
  - Electrons emitted from isotopes such as tritium and 90Sr.

    - Can travel a short distance in tissue (a few millimeters) and up to a couple of meters in air.
    - Most beta particles can be shielded by a thin layer of plastic–such as the clear face-piece of a full-face respirator.
    - Large quantities of beta-emitting radioactive materials deposited on the skin can cause relatively superficial damage (radiation burns). Like alpha-particles, they are also important if inhaled or ingested.
- Gamma (γ) rays:
    - Highly energetic non-particulate electromagnetic radiation (i.e waves not particles) capable of creating ionization.
    - They can pass through matter easily, and can result in exposure and damage to the internal organs from external sources. Dense materials (such as lead are needed to shield gamma rays.
- X-rays: Different from gamma rays *only* in their point of origin: outside of the nucleus for xrays as opposed to within it for gamma rays.
- Neutrons: Uncharged particles, important because they are emitted during the fission process and in some nondestructive testing procedures. They are very uncommon but more dangerous than gamma rays, and they are the only type of the five discussed that have the ability to make something else radioactive (neutron activation).

Common Radioisotopes

- “University Five” – 14C, 32P, 125I, 131I, 252Cf: used for isotopic labeling in biochemistry laboratories, and in medicine.
- “Industrial Three” – 192Ir, 137Cs, 60Co: 192Ir is widely used in industrial radiography to photograph large objects such as oil pipes, airplane wings, etc. 137Cs and 60Co are used in industry and are considered to be prime agents for terrorism incidents.
- “Military Five” – Tritium (3H), 235U, 238U, 239Pu, and 241Am: primarily used in the weapons complex (DOE and military).
- Fission/Activation Products – encountered in response to a nuclear detonation, a reactor accident, or a waste transportation incident. Some are volatile and, depending on the activity, can pose a significant risk to the populace.

Additional Info

Table 4 – Quick Triage Using Time to Vomiting

Dose in Gray (Gy)	Time to Vomiting (hours)	% of victims	Survivability LD 50/60
0	0	-	
1	N/A	19	
2	4.63	35	
3	2.62	54	
4	1.74	72	With intense treatment
5	1.27	86	
6	0.99	94	
7	0.79	98	
8	0.66	99	
9	0.56	100	
10	0.48	100	

Biodosimetry Based on Acute Photon-Equivalent Exposures; Waselenko, JK, "Medical Management of the Acute Radiation Syndrome: Recommendations of the Strategic National Stockpile Radiation Working Group", Ann Intern Med, 2004.

Prehospital Radiological Triage

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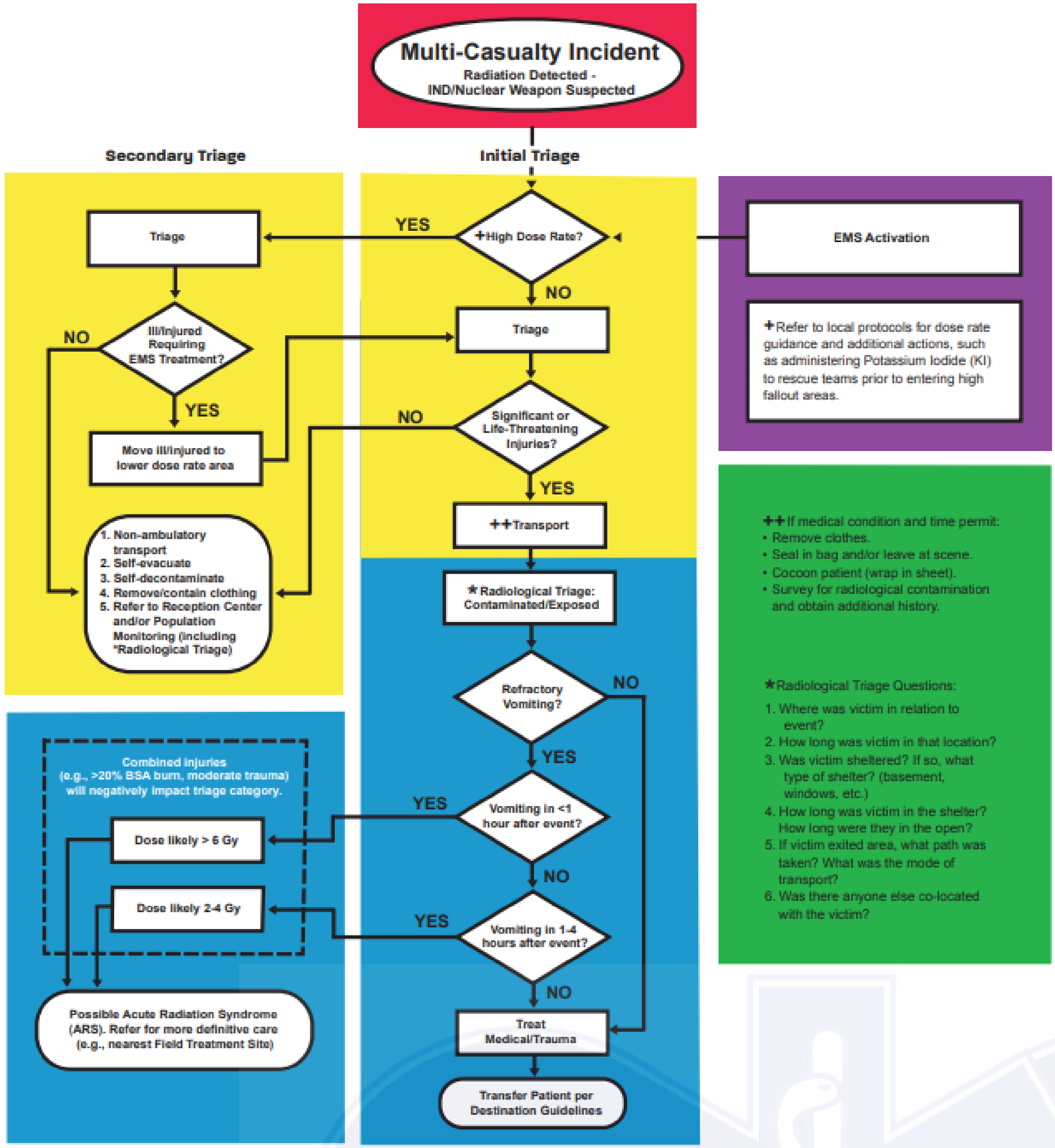

Radiation Emergency Assistance Center/Training Site (REAC/TS)

After Hours Emergency Assistance

US Department of Energy Oak Ridge Operations Center: 865.576.1005

Phone: 865.576.3131 · orise.orau.gov/reacts

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